AI INTEGRATION IN CURRICULUM IMPLEMENTATION AMONG FEMALE SCIENCE TEACHERS IN NIGERIA: A GENDER-RESPONSIVE FRAMEWORK

Bianca Uzoamaka Mbonu-Adigwe[1]; Obiageli Loretta Aniaku[1]; Christiana Ogonna Odimkpa[2] & Benson Chukwunonso Ezeanyi[2]

[1]Department of Science Education, University of Nigeria, Nsukka

[2]Department of Science Education, Alex Ekwueme Federal University, Ndufu-Alike

Corresponding author: odimkpa.ogonna@funai.edu.ng

Abstract

The integration of Artificial Intelligence (AI) into curriculum implementation represents one of the most significant opportunities for transforming teaching and learning in sub-Saharan Africa, yet it also reproduces existing structural inequalities unless approached with deliberate attention to context. This conceptual paper examines the conditions under which AI can be meaningfully and equitably integrated into curriculum implementation in Nigeria, with specific focus on female science teachers as an underrepresented group in educational technology discourse. Drawing on the Technological Pedagogical Content Knowledge (TPACK) framework, gender-responsive pedagogy, and a critical review of the empirical and policy literature, the paper analyses the opportunities, barriers, and systemic enablers that shape AI adoption in Nigerian secondary schools. Contextual evidence from a survey of 68 female science teachers in Anambra and Enugu States is incorporated to ground the conceptual argument in observable field realities, revealing a pronounced awareness-implementation gap (AI awareness M = 3.21 vs. classroom use M = 2.14) driven by infrastructural deficits, limited professional development, and gender-based constraints. Building on this analysis, the paper proposes and elaborates a Gender-Responsive Framework for AI Integration in Curriculum Implementation (GR-FAIICI), anchored on seven interdependent pillars: foundational infrastructure, teacher digital capacity, localized content, inclusive and equitable access, ethical governance, research and evidence, and multi-stakeholder collaboration. The framework advances a systems-oriented approach that positions gender responsiveness not as an add-on but as a structuring principle for AI policy and practice in Nigerian education.

Keywords: Artificial intelligence, curriculum implementation, female science teachers, Nigeria, gender-responsive framework, TPACK, educational technology, Sub-Saharan Africa

Introduction

Nigeria's educational system faces a confluence of structural challenges that constrain effective curriculum implementation and equitable learning outcomes. Despite sustained policy attention to educational reform, persistent problems - overcrowded classrooms, inadequate instructional materials, weak digital ecosystems, and limited opportunities for continuous professional development - continue to undermine the quality and consistency of science teaching across the country. These conditions are especially pronounced in public secondary schools, where teachers routinely manage large, heterogeneous classes with minimal institutional support.

Against this backdrop, Artificial Intelligence (AI) has emerged globally as a potentially transformative force in education. AI-powered tools enable personalized learning, automated assessment, intelligent tutoring, and data-driven instructional practice, offering possibilities for improving both teaching effectiveness and learner outcomes (Holmes et al., 2019; UNESCO, 2023). In principle, these capabilities are particularly

valuable in contexts like Nigeria, where teachers are under-resourced, and learners present diverse needs. However, in practice, AI adoption in Nigerian public education remains marginal, uneven, and largely disconnected from systemic educational reform (Williamson & Eynon, 2020)

A critical dimension of this challenge is gender. Female science teachers in Nigeria face compounding barriers to digital engagement - including unequal access to training, limited participation in professional networks, and socio-cultural constraints that influence confidence and institutional visibility (UNESCO, 2022; World Bank, 2025). These dynamics mean that the digitalization of education, if not explicitly designed with gender responsiveness in mind, risks reinforcing rather than reducing existing inequalities.

This paper responds to a gap in the literature at the intersection of AI integration, curriculum implementation, and gender in the Nigerian context. While empirical studies on AI adoption in African education are growing, the specific experiences of female science teachers - and the structural conditions shaping their engagement with educational technology - remain under-theorized. Conceptual frameworks that could guide policy and practice in this space are largely absent. The paper makes two primary contributions. First, it provides a theoretically grounded and empirically informed analysis of the conditions that shape AI integration for female science teachers in Nigeria. Second, it proposes a Gender-Responsive Framework for AI Integration in Curriculum Implementation (GR-FAIICI) that offers a practical and conceptual scaffold for policymakers, school leaders, teacher educators, and EdTech developers working in similar contexts.

The paper proceeds as follows. Section 2 reviews the relevant literature on AI integration, gender-responsive pedagogy, and systemic barriers in African educational contexts. Section 3 presents the theoretical framework underpinning the analysis. Section 4 describes the conceptual approach and the role of contextual survey evidence. Section 5 presents findings from the literature synthesis and survey data. Section 6 introduces and elaborates the proposed GR-FAIICI framework. Section 7 discusses implications for policy, practice, and research. Section 8 concludes.

Purpose of the Study

The main aim of this paper is to develop a theoretically grounded and empirically informed conceptual framework for the gender-responsive integration of Artificial Intelligence in curriculum implementation among female science teachers in Nigerian secondary schools. Specifically, the paper is guided by the following objectives:

1. To examine the current state of AI integration in curriculum implementation among female science teachers in Nigeria, drawing on empirical survey evidence and the scholarly literature.
2. To identify the opportunities and structural barriers that shape AI adoption for female science teachers in Nigerian secondary schools, with particular attention to infrastructural, pedagogical, and gender-related factors.
3. To analyse the theoretical foundations that can inform equitable and effective AI integration in the Nigerian educational context.
4. To propose and elaborate the Gender-Responsive Framework for AI Integration in Curriculum Implementation (GR-FAIICI), articulating its seven pillars and their interconnections.
5. To derive evidence-based implications for educational policy, professional practice, and future research from the proposed framework.

LITERATURE REVIEW

AI Integration in Curriculum Implementation

The integration of AI into educational practice has attracted growing scholarly and policy attention over the past decade. AI technologies offer a range of capabilities relevant to curriculum implementation: adaptive learning pathways, automated formative assessment, intelligent tutoring systems, content personalization, and predictive analytics that can identify learner gaps in real time (Holmes et al., 2019). These tools hold particular promise for supporting teachers in complex, resource-constrained classrooms by reducing administrative load, improving feedback quality, and enabling more differentiated instruction. Emerging evidence from diverse contexts suggests that when AI is implemented with adequate teacher preparation and institutional support, it can meaningfully improve teaching effectiveness and learner engagement (Aliyyah & Amalia, 2025; Juma et al., 2026). However, enthusiasm for AI's potential consistently outpaces the conditions required for its realization. Studies repeatedly find that teacher awareness of AI tools does not automatically translate into classroom integration (Holmes et al., 2019; Hennessy et al., 2022). The gap between knowing and doing reflects deeper issues of teacher readiness, institutional culture, and systemic support. In the Nigerian context, AI adoption faces compounding barriers rooted in infrastructural deficiency, policy fragmentation, and weak institutional readiness (Williamson & Eynon, 2020). These are not incidental limitations but structural features of the educational landscape that shape what is possible for individual teachers regardless of their motivation or competence. AI integration in Nigeria, therefore, cannot be treated as a matter of individual adoption; it requires systemic intervention.

Gender-Responsive Pedagogy and Digital Inclusion

Gender-responsive pedagogy emphasises instructional approaches, learning materials, and institutional practices that actively promote fairness and equitable participation for all learners. In the Nigerian context, research consistently shows that while teachers acknowledge the importance of gender responsiveness in principle, its practical implementation is constrained by inadequate training, weak institutional emphasis, and the absence of practical tools and guidelines (Olanrewaju et al., 2026). The relevance of gender responsiveness extends beyond student learning to encompass teacher professional experience. Digital technologies are not gender-neutral in their uptake or effects. Across sub-Saharan Africa, women and girls systematically have fewer opportunities to access digital tools, develop technology-related competencies, and participate in the professional networks through which digital knowledge circulates (UNESCO, 2022; World Bank, 2025). For female science teachers, this digital gender divide has direct implications for professional participation in AI-driven educational reform.

The intersection of gender, technology, and professional development is therefore not a secondary concern for AI integration in Nigerian education - it is central to any realistic account of what AI adoption looks like and who it reaches. Gender-responsive AI integration must go beyond questions of device access to address the broader conditions that shape confidence, pedagogical experimentation, and sustained professional engagement with new technologies.

Systemic Barriers in African Educational Contexts

Research across Nigeria and other African contexts identifies a consistent set of systemic barriers to educational technology adoption. Poor electricity supply, limited

internet connectivity, inadequate access to digital devices, high implementation costs, low institutional readiness, and insufficient technical support are repeatedly cited as primary constraints (Adedoyin & Soykan, 2020). In many Nigerian public schools, even basic ICT integration remains aspirational, making AI adoption especially challenging. These systemic conditions have important implications for how AI integration must be theorized and approached. Technology adoption in education is not a discrete event but a process shaped by school leadership, policy coherence, funding priorities, teacher preparation systems, and broader social inequalities. Isolated interventions - providing devices without connectivity, or connectivity without training - consistently fail to produce sustained change (Hennessy et al., 2022). Meaningful AI integration in Nigeria therefore, requires coordinated, multi-level reform rather than piecemeal technological investment. Adedoyin and Soykan (2020) further highlight that AI integration in African educational systems introduces ethical concerns around algorithmic accountability, data privacy, and the cultural fit of AI-generated content. These concerns reinforce the need for governance frameworks that are contextually grounded rather than imported wholesale from high-income settings.

Teacher Capacity and AI Adoption

Teacher readiness is among the most consistent predictors of successful technology integration in schools. Professional development improves teachers' confidence, competence, and willingness to integrate technology into instruction (Hennessy et al., 2022). However, in low- and middle-income countries, training programs are often short-term, generic, and disconnected from everyday classroom realities, limiting their long-term effectiveness. For AI specifically, teachers need more than technical orientation. They require opportunities to understand the pedagogical relevance of AI tools, experiment with practical classroom applications, reflect on ethical implications, and adapt generic tools to subject-specific needs. This is particularly important in science education, where AI can support simulations, inquiry-based learning, conceptual visualization, and differentiated instruction (Holmes et al., 2019). Without a deliberate bridge between technical exposure and pedagogical application, AI awareness remains shallow, and classroom use remains minimal. Nigerian teachers frequently demonstrate low technological self-efficacy in relation to emerging technologies, a pattern that is exacerbated for female teachers by unequal access to professional development opportunities. This finding underscores that building teacher capacity for AI integration must attend not only to what is taught in training programs but to who is systematically excluded from them.

Identifying the Research Gap

Despite growing interest in AI in education globally, there is a notable scarcity of scholarship that simultaneously addresses AI integration, curriculum implementation, and gender in the Nigerian context. Much existing research is either too broadly focused on educational technology adoption, primarily oriented toward student experience rather than teacher agency, or insufficiently attentive to the gendered dimensions of professional engagement with emerging technologies. Conceptual frameworks that could guide inclusive AI integration in Nigerian education are largely absent from the literature. This paper addresses that gap directly. By bringing together theoretical analysis, literature synthesis, and contextual field evidence, it constructs a framework that is both conceptually rigorous and practically relevant to the realities of Nigerian science education.

THEORETICAL FRAMEWORK

This paper is theoretically grounded in two complementary frameworks: the Technological Pedagogical Content Knowledge (TPACK) model and the principles of gender-responsive pedagogy. Together, these frameworks offer a lens for analyzing both the knowledge conditions and the socio-structural conditions that shape AI integration among female science teachers.

Technological Pedagogical Content Knowledge (TPACK)

The TPACK framework, developed by Mishra and Koehler (2006), posits that effective technology integration in teaching depends on the dynamic interaction of three knowledge domains: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Effective teaching with technology requires not merely the presence of each domain but their meaningful integration - particularly in the form of Technological Pedagogical Content Knowledge (TPACK), which captures a teacher's ability to use technology in ways that are appropriate to the subject matter and the learner. TPACK is particularly useful for analyzing AI integration because it shifts analytical attention from access to use. A teacher may have a device and internet connectivity (TK prerequisites) but lack the pedagogical imagination to deploy AI tools in ways that enhance science learning (TPACK). This framework helps explain why awareness of AI among Nigerian teachers does not straightforwardly translate into meaningful classroom application - the missing elements are often pedagogical and content-specific, not merely technical. Applying TPACK to the Nigerian context also reveals the limitations of training interventions that focus exclusively on technical skill. Professional development for AI integration must be subject-specific, classroom-relevant, and pedagogically rich if it is to produce the kind of integrated knowledge that sustains actual teaching practice.

Gender-Responsive Pedagogy as a Structural Lens

Gender-responsive pedagogy provides the structural complement to TPACK's focus on individual teacher knowledge. Where TPACK illuminates what teachers need to know and be able to do, gender-responsive pedagogy illuminates the institutional and social conditions that enable or constrain their professional development and agency. It directs attention to how gendered social arrangements - unequal access to training, differential institutional visibility, socio-cultural expectations about women's engagement with technology - shape the professional experience of female teachers. For AI integration, this means attending to the conditions under which female teachers access professional development opportunities, participate in institutional decision-making about technology adoption, and develop the confidence and self-efficacy needed to experiment with new tools. A gender-responsive approach does not treat female teachers as uniformly disadvantaged but recognises that structural inequalities operate unevenly and must be addressed through targeted, context-sensitive strategies. The combination of TPACK and gender-responsive pedagogy provides the analytical scaffolding for both the literature synthesis and the proposed framework, ensuring that the analysis addresses knowledge, practice, and structure simultaneously.

CONCEPTUAL APPROACH AND USE OF CONTEXTUAL EVIDENCE

This paper adopts a conceptual methodology that synthesizes theoretical frameworks and empirical literature to develop an original analytical framework. Conceptual papers of this type occupy an established and valued place in educational research, particularly when the aim is to address gaps in theoretical scaffolding for

emerging practice areas (Jaakkola, 2020). The paper does not make causal empirical claims; rather, it advances a framework grounded in a critical reading of the existing evidence base. To ground the conceptual analysis in observable field realities, the paper draws on contextual evidence from a structured survey conducted with 68 female science teachers in secondary schools in Anambra and Enugu States, Nigeria. The survey instrument - the Female Teachers AI Implementation Questionnaire (FTAiIQ) - measured levels of AI awareness, confidence, and classroom use, as well as perceptions of opportunities and barriers. The instrument demonstrated strong internal consistency (Cronbach's alpha = 0.88).

These data are used not as the primary basis for the paper's conclusions but as contextual evidence that motivates and illustrates the conceptual argument. They serve to demonstrate that the theoretical concerns identified in the literature - the awareness-implementation gap, the role of infrastructural deficits, the significance of gender-based constraints - manifest in concrete and measurable ways in Nigerian school settings. As such, the survey findings lend empirical credibility to the framework without requiring the paper to bear the methodological weight of a fully powered mixed-methods study. This approach is consistent with established traditions in conceptual and framework-development scholarship, where contextual evidence is used to anchor theoretical propositions and demonstrate practical relevance (Jaakkola, 2020; Rocco & Plakhotnik, 2009).

AI INTEGRATION FOR FEMALE SCIENCE TEACHERS IN NIGERIA: OPPORTUNITIES, BARRIERS, AND FIELD EVIDENCE

Opportunities: Recognizing AI's Potential

The theoretical case for AI integration in Nigerian science education is well-supported in the literature. AI tools offer the potential to reduce some of the most pressing constraints on science teaching in under-resourced settings: they can substitute for laboratory resources through simulation, differentiate instruction for heterogeneous learners, provide immediate formative feedback, and reduce the administrative burden that limits teachers' capacity for reflective practice (Holmes et al., 2019; UNESCO, 2023). Survey data from the present study corroborate this theoretical potential at the level of teacher perception. A substantial majority of respondents expressed agreement that AI improves teaching effectiveness (82%), makes lesson preparation easier (80%), increases student engagement (79%), and supports personalised learning (76%). These figures indicate that female science teachers in the study context are not resistant to AI - they are aware of its value and, under the right conditions, willing to engage with it.

This is a critical finding because it shifts the analytical frame. The problem of AI integration in Nigerian schools is not primarily one of teacher motivation or cultural resistance; it is a structural problem rooted in the conditions within which teachers work. Recognising this distinction has important implications for how interventions are designed.

The Awareness-Implementation Gap

A central finding of both the literature and the survey is the pronounced gap between awareness of AI and its actual classroom use. Survey respondents demonstrated a moderate level of AI awareness (Grand Mean = 3.21, SD = 0.84), indicating general familiarity with AI concepts and their educational potential. However, this awareness has not translated into practice: reported levels of AI use in classroom teaching were

substantially lower (Grand Mean = 2.14, SD = 0.91), and AI confidence scores were similarly weak (Grand Mean = 2.47, SD = 0.88). This awareness-implementation gap is not unique to the Nigerian context - it is a documented pattern in educational technology research more broadly (Holmes et al., 2019; Hennessy et al., 2022). What distinguishes the Nigerian situation is the depth of the structural factors that sustain the gap. In contexts with strong infrastructure and professional development systems, the gap tends to close as teachers gain experience and institutional support. In Nigeria, the gap persists because the enabling conditions for integration are themselves absent.

The TPACK framework helps explain this dynamic. Teachers in the study context may possess content knowledge and some degree of pedagogical knowledge, but their technological knowledge - and crucially their capacity to integrate the three domains - remains underdeveloped due to inadequate training, limited exposure, and constrained practice opportunities. The result is a population of teachers who understand AI in the abstract but cannot translate that understanding into effective classroom action.

Structural Barriers

The survey data confirm that structural barriers are the dominant constraint on AI integration. Poor internet access was cited by 91% of respondents, lack of electricity by 89%, and lack of training by 88% - figures that indicate near-universal experience of these constraints rather than isolated difficulties. Limited access to devices (84%), lack of institutional support (81%), and the absence of AI from curriculum guidelines (79%) round out the primary barrier profile. These findings align closely with the broader literature on educational technology adoption in sub-Saharan Africa (Adedoyin & Soykan, 2020; Guan, Yue, & Gu, 2024). They confirm that AI integration in Nigerian schools is constrained not by teachers' unwillingness but by the conditions within which they work - a distinction that has direct implications for where interventions must be targeted. The infrastructure deficit is particularly significant because it is not merely a technical inconvenience. Unreliable electricity and internet connectivity mean that even teachers who have been trained to use AI tools cannot do so consistently in practice. The result is a cycle of aspiration, frustration, and eventual disengagement that deepens the awareness-implementation gap over time.

Gender-Based Constraints

The survey data also reveal gender-specific constraints, with 63% of respondents reporting gender-related barriers to AI access. While this figure is lower than the infrastructure barriers, it is significant precisely because it is layered on top of them - female teachers face both the general structural constraints affecting all teachers and additional gender-specific barriers affecting their professional development and institutional participation. These findings align with UNESCO (2022) and World Bank (2025) research documenting the digital gender divides in sub-Saharan Africa. They also resonate with Olanrewaju et al. (2026), who found that gender disparities continue to influence access to professional development opportunities and educational resources in Nigerian secondary schools. For AI integration policy, this means that gender-neutral interventions - however well-designed - are likely to reproduce existing disparities unless they explicitly address the conditions that disadvantage female teachers.

A GENDER-RESPONSIVE FRAMEWORK FOR AI INTEGRATION IN CURRICULUM IMPLEMENTATION (GR-FAIICI)

The analysis in Section 5 establishes that AI integration in Nigerian science education is constrained by interacting structural, pedagogical, and gender-related factors that cannot be addressed in isolation. What is needed is a coherent framework that identifies the key conditions for effective and equitable AI integration, specifies the relationships between them, and provides practical guidance for policy and institutional action. This section presents and elaborates the Gender-Responsive Framework for AI Integration in Curriculum Implementation (GR-FAIICI). The GR-FAIICI is organised around seven interdependent pillars, each reflecting a critical dimension of the enabling environment for AI integration. Gender responsiveness is not a discrete component of the framework but a cross-cutting principle that informs all seven pillars. The framework is visualised in Figure 1 (described in Table 1 below) and elaborated in the subsections that follow.

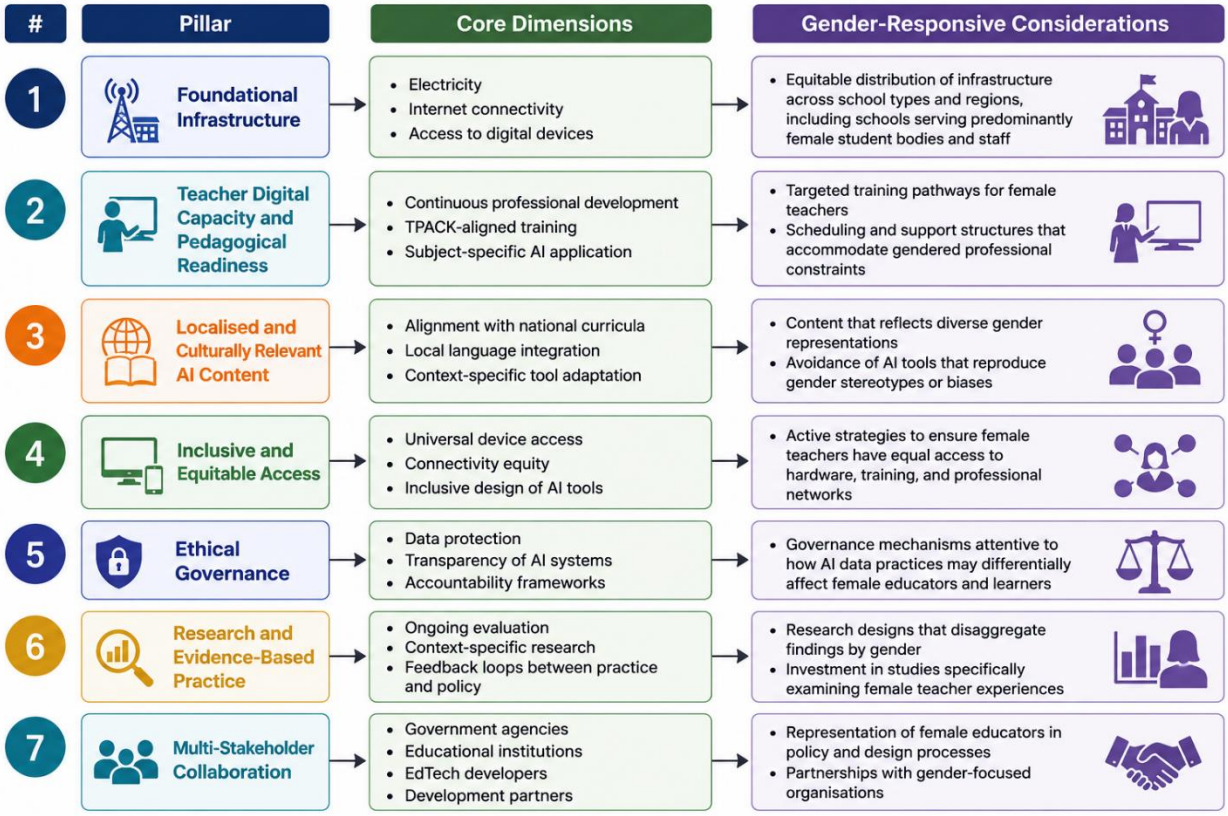

Figure 1: The GR-FAIICI Framework - Seven Pillars and Their Core Dimensions

Pillar 1: Foundational Infrastructure

Effective AI integration depends on a functional digital environment. Reliable electricity, internet connectivity, and access to devices constitute the basic enabling conditions without which all other interventions are rendered ineffective. In the Nigerian context, where 89% of survey respondents reported lack of electricity and 91% reported poor internet access as barriers, infrastructure is not a background assumption but the primary binding constraint. From a gender-responsive perspective, infrastructure investment must attend to equity as well as adequacy. Schools serving predominantly female populations, and schools where female teachers are concentrated, must be included

in digitalization plans. Infrastructure deficits are not uniformly distributed across the Nigerian educational landscape - they tend to be concentrated in lower-resourced settings that also have higher proportions of female staff. Gender-responsive infrastructure policy therefore, requires active targeting, not only system-wide improvement.

Pillar 2: Teacher Digital Capacity and Pedagogical Readiness

The survey data confirm that AI awareness does not translate into classroom use without substantial pedagogical preparation. Teachers require not just technical orientation but subject-specific training that builds the TPACK-aligned competencies needed to integrate AI meaningfully into science teaching. Professional development must be continuous, classroom-grounded, and attentive to the pedagogical demands of specific subject areas. For female teachers specifically, professional development design must account for the structural constraints that limit their participation. These include timetabling that disadvantages teachers with caregiving responsibilities, training venues and formats that limit female participation, and institutional cultures that do not prioritize female teachers' professional advancement. Gender-responsive professional development is not simply a matter of ensuring that female teachers are included in existing programs but of designing programs that are structured to reach them effectively.

Pillar 3: Localized and Culturally Relevant AI Content

Many AI tools in use in educational contexts globally were developed for high-income, English-language settings that differ substantially from the Nigerian educational environment. Their applicability is limited by language barriers, curriculum misalignment, and cultural assumptions embedded in their design. Effective AI integration in Nigerian schools therefore, requires either the adaptation of existing tools or the development of new tools that are aligned with national curricula, local languages, and cultural contexts. A gender-responsive approach to content localization must also attend to the representations and assumptions embedded in AI-generated content. Tools that reproduce gender stereotypes - in examples, illustrations, or suggested career pathways - risk reinforcing precisely the inequalities that gender-responsive education seeks to address. Content review processes should therefore include gender-competent evaluators as a standard component of EdTech procurement and development.

Pillar 4: Inclusive and Equitable Access

Inclusive access goes beyond the provision of devices and connectivity to encompass the conditions that enable meaningful use. This includes accessible training, relevant support systems, time for professional experimentation, and participation in communities of practice. For female science teachers, equitable access requires intentional strategies that address the specific barriers documented in the literature and confirmed by the survey data. This pillar reflects a central insight of gender-responsive AI integration: that neutrality in policy design is not sufficient. Policies that treat all teachers as equivalent without attending to the structural disadvantages affecting female teachers will systematically under-serve them. Inclusive access requires positive action - targeted provision, supportive structures, and institutional accountability for gender equity outcomes.

Pillar 5: Ethical Governance

AI systems in educational contexts collect and process large volumes of data about teachers and learners. Ensuring that these data are protected, that AI decision-making processes are transparent, and that accountability mechanisms are in place is essential for

building the trust on which sustained adoption depends. Adedoyin and Soykan (2020) and Guan, Yue, & Gu (2024) highlight that ethical concerns around algorithmic accountability are particularly salient in African contexts, where institutional capacity for technology governance is often limited. Ethical governance must also be gender-attentive. Data practices that profile teachers or learners by gender without appropriate safeguards can perpetuate discriminatory patterns. Governance frameworks should require gender-disaggregated reporting of AI system outcomes and include mechanisms for identifying and addressing unintended discriminatory effects.

Pillar 6: Research and Evidence-Based Practice

Sustainable AI integration depends on a continuous feedback loop between practice and evidence. Context-specific research is needed to monitor the impact of AI interventions, identify emerging challenges, and refine implementation strategies over time. The current scarcity of empirical research on AI integration for female teachers in Nigeria is itself a barrier to effective policy - it means that decisions are made without an adequate evidence base. Research investment must include studies specifically designed to examine gender dynamics in AI adoption, using methodologies and analytical frameworks capable of revealing the intersecting structural factors that shape female teachers' experiences. This paper itself represents an attempt to contribute to that evidence base, but the scale of what is needed far exceeds what any single study can provide.

6.7 Pillar 7: Multi-Stakeholder Collaboration

No single actor can produce the systemic change that effective AI integration requires. Government agencies must provide policy direction, funding, and regulatory frameworks. Educational institutions must translate policy into school-level practice. EdTech developers must build contextually appropriate, pedagogically sound, and ethically governed tools. Development partners must align their investments with national priorities and local realities.

Gender responsiveness in multi-stakeholder collaboration requires that female educators are not merely consulted but are active participants in the design and governance of AI integration initiatives. Their knowledge of classroom realities, professional constraints, and learner needs is an essential input into effective policy and tool development - and their marginalization from these processes is itself a form of the inequality that AI integration must address.

IMPLICATIONS FOR POLICY, PRACTICE, AND RESEARCH

Policy Implications: The GR-FAIICI framework has direct implications for educational policy in Nigeria and comparable contexts. At the national level, the framework calls for AI integration to be addressed as a system-wide priority, with dedicated policy frameworks that specify infrastructure investment targets, teacher professional development standards, curriculum alignment requirements, and ethical governance provisions. The current fragmentation of digital education policy in Nigeria - identified by Williamson and Eynon (2020) as a significant barrier - must be addressed through a coherent national strategy. Gender responsiveness should be written into AI education policy as a substantive requirement, not a rhetorical gesture. This means establishing gender-disaggregated targets for professional development participation, infrastructure access, and AI tool adoption; requiring gender impact assessments for EdTech procurement; and creating accountability mechanisms that make gender equity outcomes visible and actionable.

Implications for Practice: At the school and institutional levels, the framework identifies several practical priorities. School leaders should invest in creating enabling environments for AI experimentation - including reliable infrastructure, protected time for professional development, and peer learning structures that support teachers in building TPACK-aligned competencies. These efforts should be explicitly inclusive of female teachers, with targeted outreach and support where structural disadvantage is most pronounced. Teacher educators and professional development providers should redesign AI training programs to be subject-specific, classroom-grounded, and sustained over time. Single-session workshops focused on technical orientation are insufficient; effective capacity building requires iterative, reflective, and pedagogically rich learning experiences. The design of these programs should involve female science teachers as co-designers, ensuring that the content and format are aligned with their professional realities.

Implications for Research: The paper points to several priorities for future research. First, larger-scale empirical studies are needed to test the relationships between the framework's pillars and AI integration outcomes across different Nigerian states and school contexts. Second, qualitative research that centres the voices and experiences of female science teachers - through in-depth interviews, participatory action research, and longitudinal case studies - can provide the kind of nuanced, contextual knowledge that quantitative surveys cannot capture alone. Third, research is needed on the design and evaluation of gender-responsive professional development programs for AI integration in Nigerian science education, specifically. The evidence base for what works in this context is currently thin, and the field would benefit substantially from rigorous intervention studies. Fourth, EdTech developers and researchers should investigate how AI tools can be adapted or redesigned to better serve female teachers and learners in Nigerian classrooms, including through participatory design processes that involve the intended users from the outset.

Conclusion

This paper has argued that the effective and equitable integration of AI into curriculum implementation in Nigeria requires a framework that simultaneously addresses infrastructure, teacher capacity, content relevance, inclusive access, ethical governance, evidence, and multi-stakeholder collaboration - with gender responsiveness as a structuring principle running through all seven dimensions. The GR-FAIICI framework proposed here provides conceptual scaffolding for this challenge, drawing on TPACK theory, gender-responsive pedagogy, and a critical synthesis of the empirical literature. Contextual evidence from a survey of female science teachers in Anambra and Enugu States confirms that the theoretical concerns identified in the literature manifest in concrete and measurable ways in Nigerian schools. The pronounced gap between AI awareness (M = 3.21) and actual classroom use (M = 2.14), the near-universal experience of infrastructure barriers, and the significant presence of gender-specific constraints all underscore the urgency of a structured, systemic response.

AI holds genuine promise for transforming science teaching and learning in Nigeria. But that promise will remain unrealized unless it is pursued through approaches that address the structural and gendered conditions that currently constrain it. The GR-FAIICI framework offers one such approach - not as a prescriptive blueprint but as a theoretically grounded and empirically informed starting point for the policy, practice, and research conversations that are urgently needed. Future work should extend this framework through large-scale empirical testing, participatory research with female

teachers, and the development of context-specific implementation tools. The goal is not merely the adoption of AI in Nigerian classrooms but the creation of educational conditions in which all teachers - and all learners - can benefit from it equitably.

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